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PTO/SB/05 (4/98)  
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**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	MI30-052
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First Inventor or Application Identifier	Ammar Derraa
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<i>Title</i>	Cathod Assemblies (as amended)
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Express Mail Label No.

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO:

Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages 25]  
(preferred arrangement set forth below)
- Descriptive title of the Invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☐ Drawing(s) (35 U.S.C. 113) [Total Sheets 3]
4. Oath or Declaration [Total Pages 2]
- a. ☐ Newly executed (original or copy)
  - b. ☒ Copy from a prior application (37 C.F.R. § 1.63(d))  
(for continuation/divisional with Box 16 completed)
    - i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

5. ☐ Microfiche Computer Program (*Appendix*)
6. Nucleotide and/or Amino Acid Sequence Submission  
(*if applicable, all necessary*)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy (identical to computer copy)
- c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

7. ☐ Assignment Papers (cover sheet & document(s))
8. ☐ 37 C.F.R. § 3.73(b) Statement ☐ Power of Attorney  
(when there is an assignee)
9. ☐ English Translation Document (if applicable)
10. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
11. ☒ Preliminary Amendment
12. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
- \* Small Entity
13. ☐ Statement(s) ☐ Statement filed in prior application  
Status still proper and desired  
(PTO/SB/09-12)
14. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
15. ☒ Other: Check

\* NOTE FOR ITEMS 1 & 13 IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

- 16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:**

☐ Continuation ☒ Divisional ☐ Continuation-in-part (CIP) of prior application No. 09/251,262  
 Prior application information: Examiner D. Hardy Group / Art Unit: 2815

**For CONTINUATION or DIVISIONAL APPS only:** The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

## 17. CORRESPONDENCE ADDRESS

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David G. Latwesen, Ph.D.

Registration No. (Attorney/Agent)

38.533

**Signature**

Date \_\_\_\_\_

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**FEE TRANSMITTAL**

Patent fees are subject to annual revision on October 1.

These are the fees effective October 1, 1997.

Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid. See Forms PTO/SB/09-12. See 37 C.F.R. §§1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT (\$ 710.00)

**Complete if Known**

Application Number	PRIORITY: 09/251,262
Filing Date	PRIORITY: February 16, 1999
First Named Inventor	Ammar Derraa
Examiner Name	PRIORITY: D. Hardy
Group / Art Unit	PRIORITY: 2815
Attorney Docket No.	MI30-052

**METHOD OF PAYMENT (check one)**

1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:
- Deposit Account Number 23-0925
- Deposit Account Name Wells, St. John et al.
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2. ☒ Payment Enclosed:
- ☒ Check ☐ Money Order ☐ Other

**FEE CALCULATION****1. BASIC FILING FEE**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
101 790	201 395	Utility filing fee	710.00
106 330	206 165	Design filing fee	
107 540	207 270	Plant filing fee	
108 790	208 395	Reissue filing fee	
114 150	214 75	Provisional filing fee	
<b>SUBTOTAL (1)</b>			<b>(\$ 710.00)</b>

**2. EXTRA CLAIM FEES**

Total Claims	Extra Claims	Fee from below	Fee Paid
10	-20** = 0		0
Independent Claims	1	-3** = 0	0
Multiple Dependent			0

\*\*or number previously paid, if greater; For Reissues, see below

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
103 22	203 11	Claims in excess of 20	
102 82	202 41	Independent claims in excess of 3	
104 270	204 135	Multiple dependent claim, if not paid	
109 82	209 41	** Reissue independent claims over original patent	
110 22	210 11	** Reissue claims in excess of 20 and over original patent	
<b>SUBTOTAL (2)</b>			<b>(\$ 0)</b>

**FEE CALCULATION (continued)****3. ADDITIONAL FEES**

Large Entity Fee Code (\$)	Small Entity Fee Code (\$)	Fee Description	Fee Paid
105 130	205 65	Surcharge - late filing fee or oath	0.00
127 50	227 25	Surcharge - late provisional filing fee or cover sheet	0.00
139 130	139 130	Non-English specification	0.00
147 2,520	147 2,520	For filing a request for reexamination	0.00
112 920*	112 920*	Requesting publication of SIR prior to Examiner action	0.00
113 1,840*	113 1,840*	Requesting publication of SIR after Examiner action	0.00
115 110	215 55	Extension for reply within first month	0.00
116 400	216 200	Extension for reply within second month	0.00
117 950	217 475	Extension for reply within third month	0.00
118 1,510	218 755	Extension for reply within fourth month	0.00
128 2,060	228 1,030	Extension for reply within fifth month	0.00
119 310	219 155	Notice of Appeal	0.00
120 310	220 155	Filing a brief in support of an appeal	0.00
121 270	221 135	Request for oral hearing	0.00
138 1,510	138 1,510	Petition to institute a public use proceeding	0.00
140 110	240 55	Petition to revive - unavoidable	0.00
141 1,320	241 660	Petition to revive - unintentional	0.00
142 1,320	242 660	Utility issue fee (or reissue)	0.00
143 450	243 225	Design issue fee	0.00
144 670	244 335	Plant issue fee	0.00
122 130	122 130	Petitions to the Commissioner	0.00
123 50	123 50	Petitions related to provisional applications	0.00
126 240	126 240	Submission of Information Disclosure Stmt	0.00
581 40	581 40	Recording each patent assignment per property (times number of properties)	0.00
146 790	246 395	Filing a submission after final rejection (37 CFR 1.129(a))	0.00
149 790	249 395	For each additional invention to be examined (37 CFR 1.129(b))	0.00
Other fee (specify) _____			0.00
Other fee (specify) _____			0.00

\* Reduced by Basic Filing Fee Paid

**SUBTOTAL (3) (\$ 0.00)****SUBMITTED BY**Typed or Printed Name David G. Latwesen, Ph.D.Signature [Signature]Date 11/13/00**Complete (if applicable)**Reg. Number 38,533

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

priority Application Serial No. .... 09/251,262  
priority Filing Date .... February 16, 1999  
Inventor ..... Ammar Derraa  
Assignee ..... Micron Technology, Inc.  
priority Group Art Unit ..... 2815  
priority Examiner ..... D. Hardy  
Attorney's Docket No. .... MI30-052  
Title: Cathode Assemblies

**PRELIMINARY AMENDMENT**

To: Box Patent Application  
Assistant Commissioner for Patents  
Washington, D.C. 20231

From: David G. Latwesen, Ph.D. (Tel. 509-624-4276; Fax 509-838-3424)  
Wells, St. John, Roberts, Gregory & Matkin P.S.  
601 W. First Avenue, Suite 1300  
Spokane, WA 99201-3828

**AMENDMENTS**

**In the Specification**

Replace the title with --Cathode Assemblies--.

At p. 1, before the "Technical Field" section, insert

**--RELATED PATENT DATA**

This patent resulted from a divisional application of U.S. Patent  
Application Serial No. 09/251,262, which was filed on February 16,  
1999.--.

1 **Amended Claims**

2 Cancel claims 1-52.

3  
4 **REMARKS**

5 Claims 1-52 are canceled, leaving claims 53-62 pending in the  
6 application. Applicant requests substantive examination of the pending  
7 claims.

8 Respectfully submitted,

9  
10 Dated: 11/13/00

By: 

11 David G. Latwesen, Ph.D.  
12 Reg. No. 38,533  
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EL169838264

EL465852811

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

**APPLICATION FOR LETTERS PATENT**

\* \* \* \* \*

**Methods Of Treating Regions Of Substantially  
Upright Silicon-comprising Structures, Methods Of  
Treating Silicon-comprising Emitter Structures,  
Methods Of Forming Field Emission Display  
Devices, And Cathode Assemblies**

\* \* \* \* \*

INVENTOR

Ammar Derraa

ATTORNEY'S DOCKET NO. MI30-036

**Methods Of Treating Regions Of Substantially Upright Silicon-comprising Structures, Methods Of Treating Silicon-comprising Emitter Structures, Methods Of Forming Field Emission Display Devices, And Cathode Assemblies**

## PATENT RIGHTS STATEMENT

This invention was made with Government support under Contract No. DABT63-97-C-0001 awarded by Advanced Research Projects Agency (ARPA). The Government has certain rights in this invention.

## TECHNICAL FIELD

The invention pertains to methods of treating substantially upright silicon-comprising structures, such as, for example, methods of treating silicon-comprising emitter structures. In particular aspects, the invention pertains to methods of forming field emission display devices. In other particular aspects, the invention pertains to cathode assemblies.

## BACKGROUND OF THE INVENTION

Silicon-comprising field emitters are currently being designed and incorporated into field emission display devices, and show promise as candidates for electron sources in vacuum microelectronic devices. It is generally desirable to fabricate the emitters to have tips that are as sharp as possible, as such can improve control of electron emission from the tips. For instance, clarity, or resolution, of a field emission display is a function of, among other things, emitter tip sharpness. As sharper

1 emitter tips can produce higher resolution displays than less sharp  
2 emitter tips, numerous methods have been proposed for fabrication of  
3 very sharp emitter tips (i.e., emitter tips having tip radii of 100  
4 nanometers or less).

5       Fabrication of very sharp tips has, however, proved difficult.  
6 Accordingly, other methods, besides simply sharpening emitter tips, have  
7 been proposed for improving electron emission from emitters. Among  
8 such other methods are procedures for treating silicon-comprising emitters  
9 to convert the silicon to porous silicon, and procedures for treating  
10 silicon-comprising field emitters to coat the emitters with materials having  
11 lower work function properties than silicon. Such materials include, for  
12 example, diamond, cesium (such as, for example, cesiated carbon) and  
13 boronitride (the boronitride can be undoped, or doped with, for example,  
14 sulfur).

15       The above-discussed procedures of treating silicon-comprising  
16 emitters show promise for improving emission from individual emitters,  
17 as well as for improving uniformity of emission across arrays of emitters.  
18 Accordingly, it would be desirable to develop methods of fabricating  
19 emitters wherein emitter treatments are incorporated into the emitter  
20 fabrication processes.

1        SUMMARY OF THE INVENTION

2            In one aspect, the invention encompasses a method of treating the  
3        end portions of an array of substantially upright silicon-comprising  
4        structures. A substrate having a plurality of substantially upright silicon-  
5        comprising structures extending thereover is provided. The substantially  
6        upright silicon-comprising structures have base portions, and have end  
7        portions above the base portions. A masking layer is formed over the  
8        substrate to cover the base portions of the substantially upright silicon-  
9        comprising structures while leaving the end portions exposed. While the  
10       masking layer covers the base portions, the end portions are exposed to  
11       conditions which alter the end portions relative to the base portions.

12           In another aspect, the invention encompasses a method of treating  
13        the ends of an array of silicon-comprising emitter structures. A  
14        substrate having a plurality of silicon-comprising emitter structures  
15        thereover is provided. The emitter structures have base portions and  
16        ends above the base portions. A layer of spin-on-glass is formed over  
17        the substrate. The layer of spin-on-glass covers the base portions of the  
18        emitter structures and leaves the ends exposed. While the layer of spin-  
19       on-glass covers the base portions, the ends are exposed to conditions  
20       which alter the ends relative to the base portions.

21           In yet another aspect, the invention encompasses a cathode  
22        assembly which includes a plurality of silicon-comprising emitter structures  
23        projecting over a substrate. The emitter structures have base portions



1 and ends above the base portions, and the ends comprise a different  
2 material than the base portions.

### 3 4 **BRIEF DESCRIPTION OF THE DRAWINGS**

5 Preferred embodiments of the invention are described below with  
6 reference to the following accompanying drawings.

7 Fig. 1 is a diagrammatic, cross-sectional, fragmentary view of a  
8 portion of an emitter array assembly illustrated at a preliminary step of  
9 a method of the present invention.

10 Fig. 2 is a view of the Fig. 1 assembly shown at a processing step  
11 subsequent to that of Fig. 1.

12 Fig. 3 is a view of the Fig. 1 assembly shown at a processing step  
13 subsequent to that of Fig. 2.

14 Fig. 4 is a view of the Fig. 1 assembly shown at a processing step  
15 subsequent to that of Fig. 1 in accordance with a second embodiment  
16 method of the present invention.

17 Fig. 5 is a view of the Fig. 4 assembly shown after a first  
18 embodiment treatment process.

19 Fig. 6 is a view of the Fig. 4 assembly shown after a second  
20 embodiment treatment process.

21 Fig. 7 is a fragmentary, diagrammatic, cross-sectional view of a  
22 field emission display incorporating the treated emitters of Fig. 6.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

This disclosure of the invention is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

In one aspect, the invention encompasses methods of treating portions of substantially upright silicon-comprising structures (such as, for example, silicon-comprising emitter structures), while leaving other portions untreated. In particular embodiments, the methodology can be utilized for treating tip regions (i.e., apexes) of silicon-comprising emitter structures, while leaving base regions untreated. Such can advantageously enable modification of electron emitting portions of emitter structures, while not altering physical properties of underlying portions of the emitter structures. Specific embodiments are described with reference to Figs. 1-6.

Referring to Fig. 1, a fragment 10 of a semiconductive material construction is illustrated at a preliminary step of a method of the present invention. Fragment 10 comprises a glass plate 12, a first semiconductive material layer 14 overlying glass plate 12, and emitter structures 20 overlying first semiconductive material layer 14. Emitter structures 20 comprise a second semiconductive material 16. Semiconductive material 14 can comprise either p-type doped or n-type doped semiconductive material, (such as, for example, monocrystalline silicon), and semiconductive material 16 can comprise doped

1 polycrystalline silicon (polysilicon) material, or, in specific embodiments,  
2 consist essentially of conductively doped polysilicon. Materials 12, 14  
3 and 16 together comprise a conventional emitter tip array construction,  
4 and can be formed by conventional methods.

5 To aid in interpretation of this disclosure and the claims that  
6 follow, it is noted that layer 14 can be referred to as a "semiconductive  
7 substrate". More specifically, the term "semiconductive substrate" is  
8 defined to mean any construction comprising semiconductive material,  
9 including, but not limited to, bulk semiconductive materials (either alone  
10 or in assemblies comprising other materials thereon), and semiconductive  
11 material layers (either alone or in assemblies comprising other materials).  
12 The term "substrate" refers to any supporting structure, including, but  
13 not limited to, the semiconductive substrates described above.

14 Emitter structures 20 represent a portion of an array of emitter  
15 structures. Such array can be referred to as a "cathode array," as the  
16 emitters can be incorporated as cathodes in electron emission devices.  
17 Each of emitter structures 20 is a substantially upright silicon-comprising  
18 structure comprising a base portion 22 and an end portion 24 above the  
19 base portion (end portion 24 can also be referred to as an apex, or tip).

20 A next aspect of the shown exemplary embodiment comprises  
21 forming a masking layer over base portions 22 to protect base  
22 portions 22 from subsequent conditions. Exemplary methods for forming  
23 the masking layer are described with reference to Figs. 2-4, with Figs. 2

1 and 3 illustrating a first embodiment method, and Fig. 4 illustrating a  
2 second embodiment method.

3 Referring to Fig. 2, a masking layer 30 is provided over  
4 semiconductive material 14 and over emitter structures 20. Masking  
5 material 30 is preferably provided to be thinner over apexes 24 than  
6 over base regions 22. Such can be accomplished, for example, by  
7 applying material 30 as a liquid. Exemplary processes include applying  
8 material 30 through spin-on-glass methodologies, or through so-called  
9 "Flowfill™" methodologies. In Flowfill™ methodologies, material 30 is  
10 initially provided as silanol (or an organic derivative of silanol). The  
11 silanol can be subsequently converted to silicon dioxide through  
12 conventional treatment methodologies.

13 Referring to Fig. 3, material of layer 30 is removed from over  
14 apexes 24, but left over base regions 22. In embodiments in which  
15 layer 30 comprises either spin-on-glass or silicon dioxide, such can be  
16 accomplished by dipping apexes 24 in a hydrofluoric acid-comprising  
17 material. For instance, if material 30 comprises spin-on-glass having a  
18 thickness of less than 50 Å over apexes 24, the selective removal of  
19 material 30 from over apexes 24 can comprise a dip in a hydrofluoric  
20 acid solution for about five seconds.

21 Referring to Fig. 4, another method of applying material 30 over  
22 emitters 20 is to utilize conditions which form material of layer 30 only  
23 over base regions 22, and not over apexes 24. Such conditions can

1 include applying material of layer 30 as a liquid, and adjusting the  
2 viscosity of such liquid to effectively have the material run off the steep  
3 surfaces of apexes 24. The liquid material of layer 30 then collects over  
4 layer 14 to a level which covers base regions 22.

5 Regardless of whether the embodiment of Figs. 2 and 3 is utilized,  
6 or the embodiment of Fig. 4 is utilized, the result is a construction  
7 having base regions 22 of emitters 20 protected by a masking layer 30,  
8 while apexes 24 are exposed through the masking layer 30.

9 Figs. 5 and 6 illustrate methods of treating apexes 24 with  
10 conditions which alter apex regions 24 relative to base regions 22.  
11 Fig. 5 illustrates first embodiment processing conditions, and Fig. 6  
12 illustrates second embodiment processing conditions.

13 Referring to Fig. 5, a low work function material 40 is provided  
14 over apex regions 24 and over masking layer 30. The term "low work  
15 function" is used herein to refer to materials having lower work  
16 functions than material 16. As discussed above, in particular applications  
17 material 16 comprises silicon. In such particular applications "low work  
18 function" can refer to materials having lower work functions than silicon.  
19 In applications in which material 16 comprises silicon, low work function  
20 material 40 can comprise, for example, diamond, cesium (such as, for  
21 example, cesiated carbon) or boronitride (such as, for example, sulfur  
22 doped boronitride). The provision of low work function material 40  
23 over and against apexes 24 can alter electron emission properties of

emitters 20. Specifically, low work function material 40 can increase electron emission across the array of emitters 20. By selectively forming low work function material 40 only against apexes 24, and not against base regions 22, the methodology of the present invention can avoid adversely affecting physical properties of base region 22 with the low work function material of layer 40. Potential adverse effects that could occur if low work function material 40 were provided against base region 22 include spurious electron emission from the base regions of emitters 20. Accordingly, the selective provision of low work function material 40 over only apexes 24 of emitters 20 can form improved emitter devices relative to devices having low work function material provided over an entire surface (i.e., both a base region and an apex region) of an emitter structure.

After formation of low work function material 40 over apexes 24, the construction 10 can be incorporated into, for example, a field emission display device. Masking material 30 and low work function material 40 can be removed from between emitters 20 prior to incorporation in the device. Such removal can be accomplished by, for example, photolithographic processing wherein a photoresist mask is utilized to protect apexes 24 while materials of layers 30 and 40 are etched from between the apexes. Suitable etching conditions can include, for example, HF based solutions or other etchants depending on the low work function material.

Referring to Fig. 6, an alternative method of treating apex regions 24 is illustrated. Specifically, apex regions 24 have been subjected to processing which forms porous silicon (represented by stippling in Fig. 6) within the apex regions. Such formation of porous silicon can increase electron emission and improve uniformity across an array of emitters 20, and can also improve a quality of electron emission from individual emitters 20 of the array. The formation of porous silicon at tip regions 24 can be accomplished by exposing fragment 10 to electrochemical etching in the presence of hydrofluoric acid. During such exposure, layer 30 protects base portions 22 so that apex regions 24 are rendered more porous than base portions 22 by the electrochemical etching. The electrochemical etching procedure can vary depending on whether silicon-comprising material 16 of emitter structures 20 is doped with an n-type material or a p-type material. Specifically, if silicon-comprising material 16 is doped with an n-type material, tip regions 24 are preferably exposed to light during the electrochemical etching. The light can be generated by, for example, a tungsten lamp. If, on the other hand, silicon-comprising material 16 is doped with a p-type material, the electrochemical etching preferably occurs in the dark.

After tip regions 24 have been rendered porous, masking layer 30 can be removed. Methods for removing masking layer 30 can include, for example, photolithographic processing wherein photoresist blocks are formed to protect apex regions 24. Subsequently, the material of

1 layer 30 that is between apex regions 24 is exposed to etching  
2 conditions which remove such material from over silicon-comprising  
3 layer 14. The etching conditions can include, for example, HF based  
4 solutions or other etchants depending on the masking material.

5 Fig. 7 illustrates the porous tipped emitter devices 20 of Fig. 6  
6 incorporated into a field emission display device 70. Field emission  
7 display device 70 includes dielectric regions 72, spacers 73, an  
8 extractor 74, and a luminescent screen 76. Screen 76 is associated with  
9 a face plate 80, and emitters 20 are part of a base plate structure 82.  
10 Device 70 is constructed with face plate 80 spaced from base plate 82.  
11 Techniques for forming field emission displays are described in U.S. Pat.  
12 Nos. 5,151,061; 5,186,670 and 5,210,472; hereby expressly incorporated by  
13 reference herein.

14 In compliance with the statute, the invention has been described  
15 in language more or less specific as to structural and methodical  
16 features. It is to be understood, however, that the invention is not  
17 limited to the specific features shown and described, since the means  
18 herein disclosed comprise preferred forms of putting the invention into  
19 effect. The invention is, therefore, claimed in any of its forms or  
20 modifications within the proper scope of the appended claims  
21 appropriately interpreted in accordance with the doctrine of equivalents.  
22  
23



1     CLAIMS:

2           1.     A method of treating portions of an array of substantially  
3     upright silicon-comprising structures, comprising:

4           providing a substrate having a plurality of substantially upright  
5     silicon-comprising structures extending thereover, the substantially upright  
6     silicon-comprising structures having base portions and end portions above  
7     the base portions;

8           forming a masking layer over the substrate, the masking layer  
9     covering the base portions of the substantially upright silicon-comprising  
10    structures and leaving the end portions exposed; and

11          while the masking layer covers the base portions, subjecting the  
12    exposed end portions to conditions which alter the end portions relative  
13    to the base portions.

14  
15          2.     The method of claim 1 wherein the forming comprises:

16          depositing the masking layer over the substrate to have a greater  
17    thickness over the base portions than over the end portions; and

18          removing the deposited masking layer from over the end portions  
19    to expose the end portions.

20  
21          3.     The method of claim 1 wherein the masking layer comprises  
22    spin-on-glass.

23

1           4.     The method of claim 1 wherein the masking layer comprises  
2 silicon dioxide.

3  
4           5.     The method of claim 1 wherein the subjecting comprises  
5 subjecting the end portions to conditions which render the end portions  
6 more porous than the base portions.

7  
8           6.     The method of claim 5 wherein subjecting comprises  
9 electrochemical etching in the presence of HF.

10  
11          7.     The method of claim 5 wherein the silicon of the upright  
12 structure is doped with an n-type material, and wherein the subjecting  
13 comprises electrochemical etching in the presence of HF and light.

14  
15          8.     The method of claim 5 wherein the silicon of the upright  
16 structure is doped with an p-type material, and wherein the subjecting  
17 comprises electrochemical etching in the presence of HF.

18  
19          9.     The method of claim 1 wherein the subjecting comprises  
20 subjecting the end portions to conditions which cover the end portions  
21 with a coating material.

22

23

1           10. The method of claim 9 wherein the coating material  
2 comprises a lower work function than silicon.

3  
4           11. The method of claim 9 wherein the coating material  
5 comprises diamond.

6  
7           12. The method of claim 9 wherein the coating material  
8 comprises boron nitride.

9  
10          13. The method of claim 9 wherein the coating material  
11 comprises sulfur-doped boron nitride.

12  
13          14. The method of claim 9 wherein the coating material  
14 comprises cesium.

15  
16          15. The method of claim 9 wherein the coating material  
17 comprises cesiated carbon.

1           16. A method of treating the ends of an array of silicon-  
2 comprising emitter structures, comprising:

3           providing a substrate having a plurality of silicon-comprising emitter  
4 structures thereover, the emitter structures having base portions and ends  
5 above the base portions;

6           forming a layer over the substrate, the layer covering the base  
7 portions of the emitter structures and leaving the ends exposed; and

8           while the layer covers the base portions, subjecting the ends to  
9 conditions which alter the ends relative to the base portions.

10  
11           17. The method of claim 16 wherein the subjecting comprises  
12 subjecting the ends to conditions which render the ends more porous  
13 than the base portions.

14  
15           18. The method of claim 17 wherein subjecting comprises  
16 electrochemical etching in the presence of HF.

17  
18           19. The method of claim 17 wherein the silicon of the upright  
19 structure is doped with an n-type material, and wherein the subjecting  
20 comprises electrochemical etching in the presence of HF and light.

1           20. The method of claim 17 wherein the silicon of the upright  
2 structure is doped with an p-type material, and wherein the subjecting  
3 comprises electrochemical etching in the presence of HF.  
4

5           21. The method of claim 16 wherein the subjecting comprises  
6 subjecting the ends to conditions which cover the ends with a coating  
7 material.  
8

9           22. The method of claim 21 wherein the coating material  
10 comprises a lower work function than silicon.  
11

12           23. The method of claim 21 wherein the coating material  
13 comprises diamond.  
14

15           24. The method of claim 21 wherein the coating material  
16 comprises boron nitride.  
17

18           25. The method of claim 21 wherein the coating material  
19 comprises sulfur-doped boron nitride.  
20

21           26. The method of claim 21 wherein the coating material  
22 comprises cesium.  
23

1           27. The method of claim 21 wherein the coating material  
2 comprises cesiated carbon.

3  
4           28. A method of treating the ends of an array of silicon-  
5 comprising emitter structures, comprising:

6           providing a substrate having a plurality of silicon-comprising emitter  
7 structures thereover, the emitter structures having base portions and  
8 pointed apexes above the base portions;

9           forming a layer of spin-on-glass over the substrate, the layer of  
10 spin-on-glass covering the base portions of the emitter structures and  
11 leaving the apexes exposed; and

12           while the layer of spin-on-glass covers the base portions, subjecting  
13 the apexes to conditions which alter the apexes relative to the base  
14 portions.

15  
16           29. The method of claim 28 wherein the subjecting comprises  
17 subjecting the apexes to conditions which render the apexes more porous  
18 than the base portions.

19  
20           30. The method of claim 29 wherein subjecting comprises  
21 electrochemical etching in the presence of HF.  
22  
23

1           31. The method of claim 29 wherein the silicon of the upright  
2 structure is doped with an n-type material, and wherein the subjecting  
3 comprises electrochemical etching in the presence of HF and light.

4  
5           32. The method of claim 29 wherein the silicon of the upright  
6 structure is doped with an p-type material, and wherein the subjecting  
7 comprises electrochemical etching in the presence of HF.

8  
9           33. The method of claim 28 wherein the subjecting comprises  
10 subjecting the apexes to conditions which cover the apexes with a coating  
11 material.

12  
13           34. The method of claim 33 wherein the coating material  
14 comprises a lower work function than silicon.

15  
16           35. The method of claim 33 wherein the coating material  
17 comprises diamond.

18  
19           36. The method of claim 33 wherein the coating material  
20 comprises boron nitride.

1           37. The method of claim 33 wherein the coating material  
2 comprises sulfur-doped boron nitride.

3  
4           38. The method of claim 33 wherein the coating material  
5 comprises a cesiated carbon film.

6  
7           39. A method of forming a field emission display device,  
8 comprising:

9           forming a cathode array over a base plate, the cathode array  
10 comprising emitter structures having base portions and ends above the  
11 base portions;

12           forming a layer of spin-on-glass over the cathode array, the layer  
13 of spin-on-glass covering the base portions of the emitter structures and  
14 leaving the ends exposed;

15           while the layer of spin-on-glass covers the base portions, subjecting  
16 the ends to conditions which alter the ends relative to the base portions;  
17 and

18           joining the base plate to a face plate in a configuration wherein  
19 the face plate is spaced from the base plate.  
20  
21  
22  
23



1           40. The method of claim 39 further comprising removing the  
2 spin-on-glass from over the base portions prior to joining the base plate  
3 to the face plate.

4  
5           41. The method of claim 39 wherein the spin-on-glass is not  
6 removed from over the base portions prior to joining the base plate to  
7 the face plate.

8  
9           42. The method of claim 39 wherein the ends terminate in sharp  
10 apexes before the subjecting.

11  
12           43. The method of claim 39 wherein the subjecting comprises  
13 subjecting the ends to conditions which render the ends more porous  
14 than the base portions.

15  
16           44. The method of claim 43 wherein subjecting comprises  
17 electrochemical etching in the presence of HF.

18  
19           45. The method of claim 43 wherein the silicon of the upright  
20 structure is doped with an n-type material, and wherein the subjecting  
21 comprises electrochemical etching in the presence of HF and light.  
22  
23

1           46. The method of claim 43 wherein the silicon of the upright  
2 structure is doped with an p-type material, and wherein the subjecting  
3 comprises electrochemical etching in the presence of HF.  
4

5           47. The method of claim 39 wherein the subjecting comprises  
6 subjecting the ends to conditions which cover the ends with a coating  
7 material.  
8

9           48. The method of claim 47 wherein the coating material  
10 comprises a lower work function than silicon.  
11

12           49. The method of claim 47 wherein the coating material  
13 comprises diamond.  
14

15           50. The method of claim 47 wherein the coating material  
16 comprises boron nitride.  
17

18           51. The method of claim 47 wherein the coating material  
19 comprises sulfur-doped boron nitride.  
20

21           52. The method of claim 47 wherein the coating material  
22 comprises cesium.  
23

1           53. A cathode assembly comprising a plurality of silicon-  
2 comprising emitter structures projecting over a substrate, the emitter  
3 structures having base portions and ends above the base portions, the  
4 ends comprising a different material than the base portions.

5  
6           54. The assembly of claim 53 wherein the emitter structures  
7 comprise conductively doped polysilicon.

8  
9           55. The assembly of claim 53 wherein the ends terminate in  
10 pointed apexes.

11  
12           56. The assembly of claim 53 wherein the emitter structures  
13 consist essentially of conductively doped silicon.

14  
15           57. The assembly of claim 53 wherein the emitter structures  
16 consist essentially of conductively doped polysilicon.

17  
18           58. The assembly of claim 53 wherein the ends comprise porous  
19 silicon and the base portions comprise non-porous silicon.

1           59. The assembly of claim 53 wherein the ends are coated with  
2 a material having a lower work function than silicon and the base  
3 portions are not coated with such material.

4  
5           60. The assembly of claim 59 wherein the material comprises  
6 diamond.

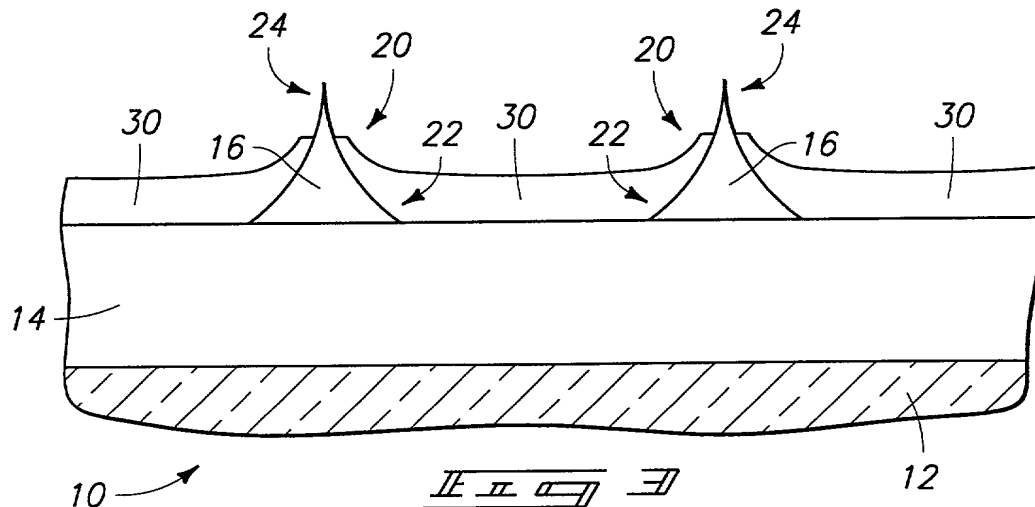
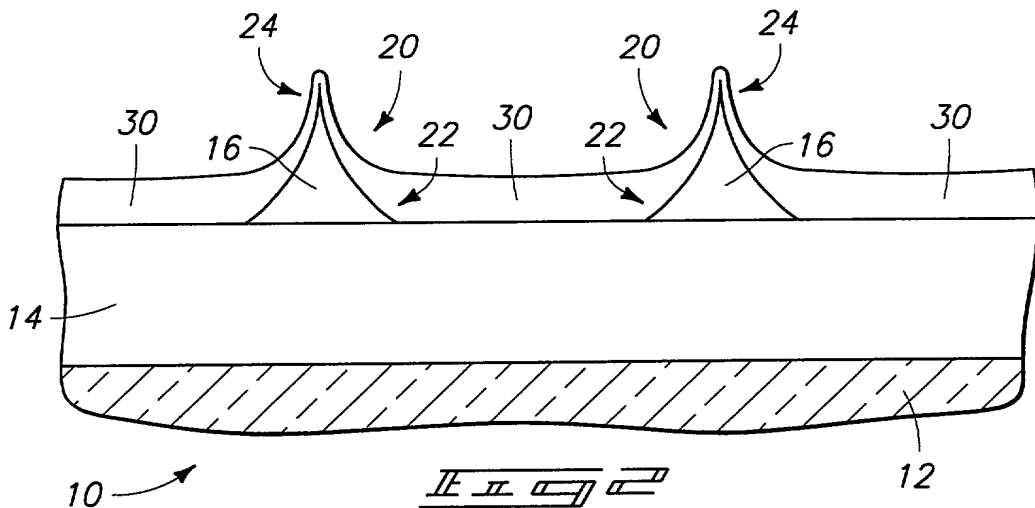
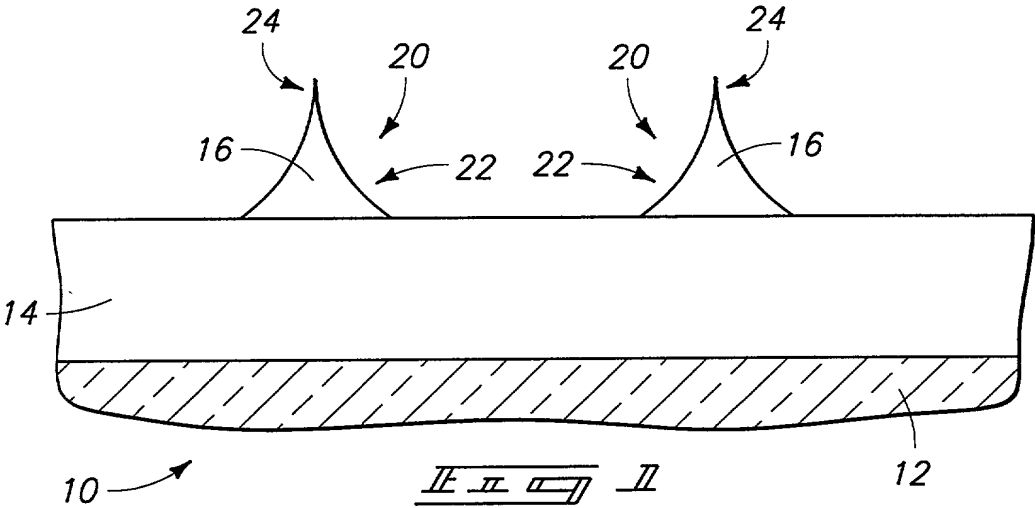
7  
8           61. The assembly of claim 59 wherein the material comprises  
9 boron nitride.

10  
11           62. The assembly of claim 59 wherein the material comprises  
12 cesium.

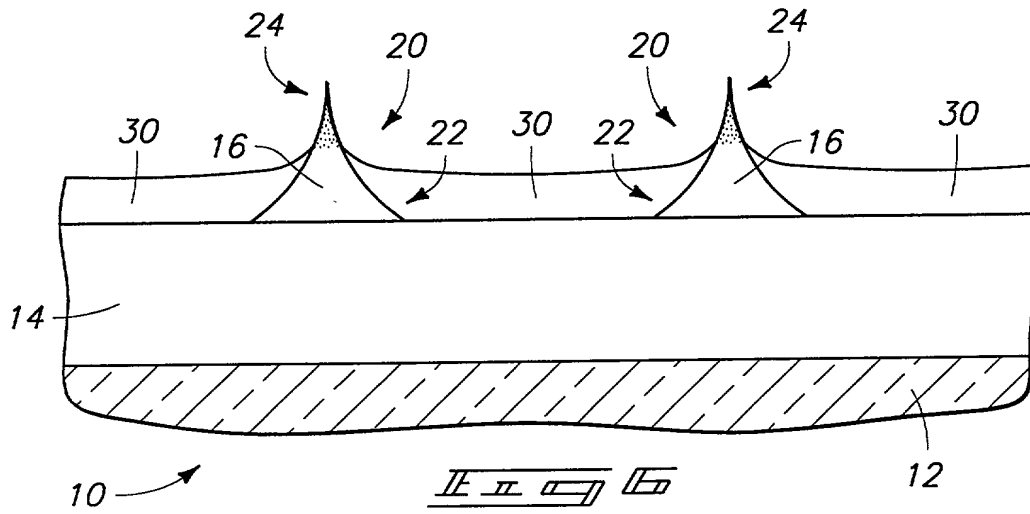
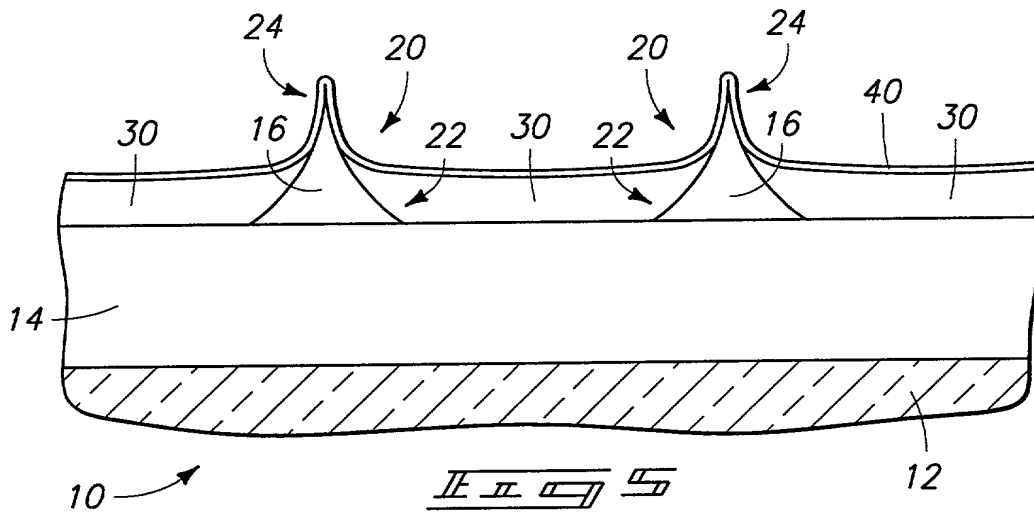
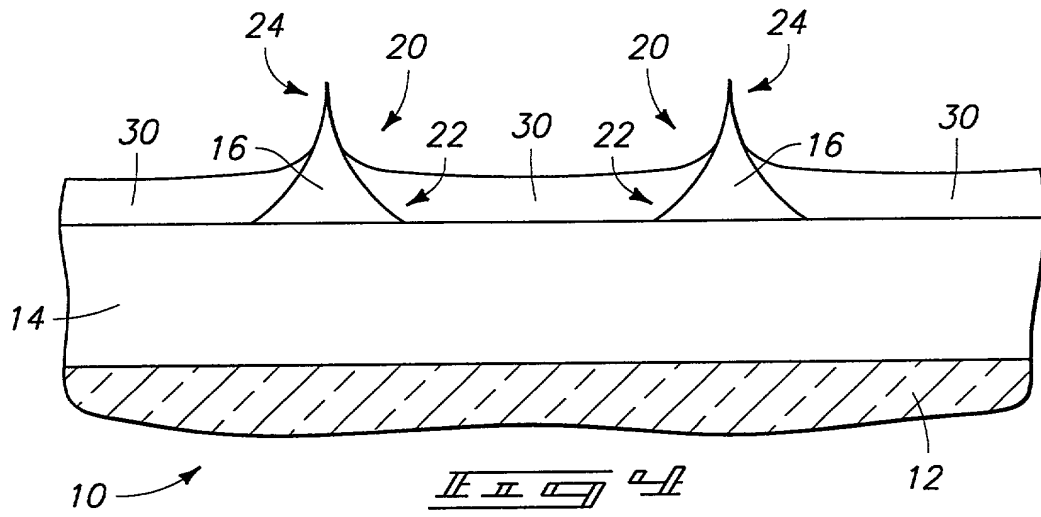
## ABSTRACT OF THE DISCLOSURE

In one aspect, the invention encompasses a method of treating the end portions of an array of substantially upright silicon-comprising structures. A substrate having a plurality of substantially upright silicon-comprising structures extending thereover is provided. The substantially upright silicon-comprising structures have base portions, and have end portions above the base portions. A masking layer is formed over the substrate to cover the base portions of the substantially upright silicon-comprising structures while leaving the end portions exposed. The end portions are then exposed to conditions which alter the end portions relative to the base portions. In another aspect, the invention encompasses a method of treating the ends of an array of silicon-comprising emitter structures. A substrate having a plurality of silicon-comprising emitter structures thereover is provided. The emitter structures have base portions and ends above the base portions. A layer of spin-on-glass is formed over the substrate. The layer of spin-on-glass covers the base portions of the emitter structures and leaves the ends exposed. The ends are then exposed to conditions which alter the ends relative to the base portions. In yet another aspect, the invention encompasses a cathode assembly which includes a plurality of silicon-comprising emitter structures projecting over a substrate. The emitter structures have base portions and ends above the base portions, and the ends comprise a different material than the base portions.

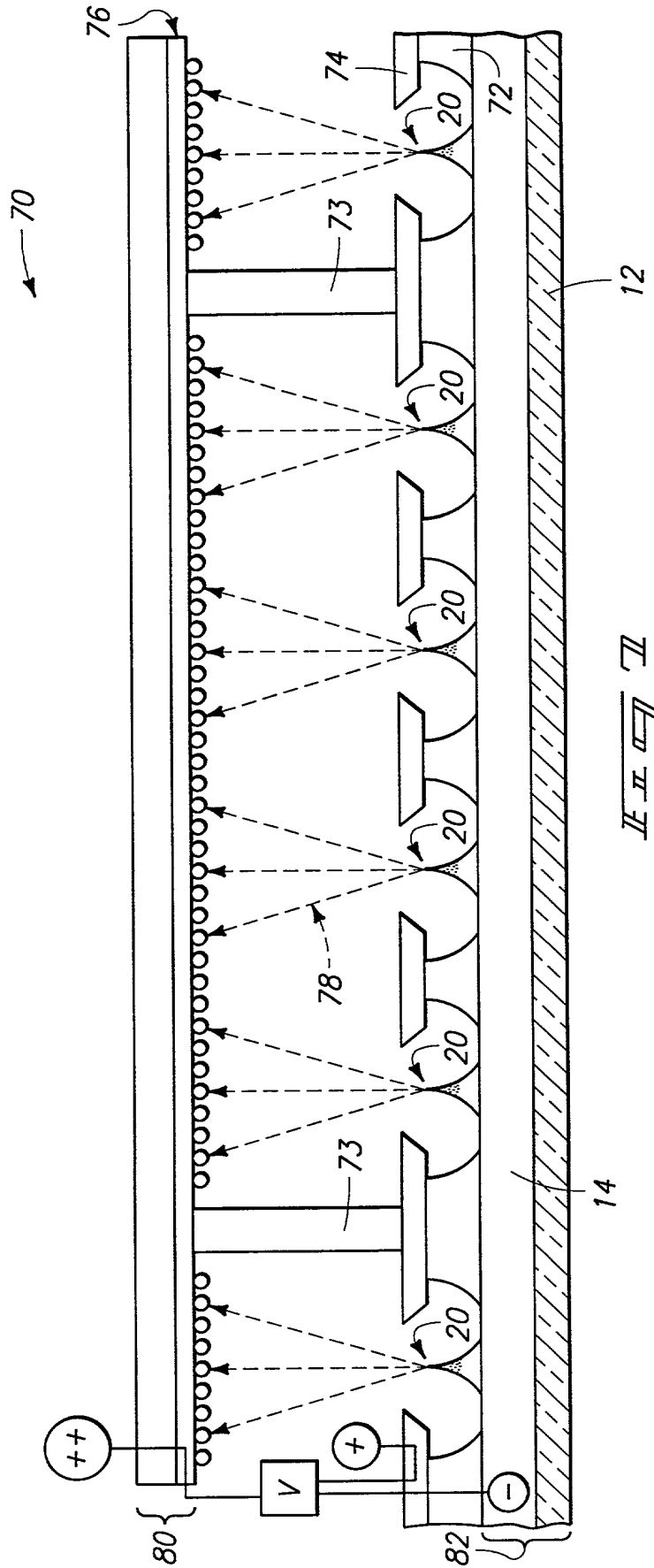
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3/3



11.11.11



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